



## Medium and large-sized mammals in a Cerrado area of the state of Goiás, Brazil

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**Abstract:** Brazilian mammal fauna is considered to be the richest of the Neotropical region. However, in several regions of the country, there are gaps in the knowledge of its mammal fauna. Thus, we conducted a survey of the medium and large-sized mammal species in the fragmented Cerrado region in the southeast area of the state of Goiás. Nonlinear transects were conducted in 28 sessions over 13 months using direct observation methods, indirect observation methods (scratches, footprints, feces and lairs) and camera trapping. Twenty-five species belonging to eight orders were recorded. The species richness estimated by the Jackknife 1 method was 24.89 ( $\pm 1.61$ ) species in the transects and 16.88 ( $\pm 1.29$ ) species in camera trap, with stabilization of the species accumulation curves. Among the recorded species, 5 were endangered at the national level, and three were globally endangered. The high species richness found in the area in addition to the presence of endangered species highlights the need for conservation measures for the study site.

**Key words:** mammals, species richness, hotspot, inventory, footprints

### INTRODUCTION

Brazil has a rich mammal fauna, consisting of 701 species (Paglia et al. 2012), and is the richest country in the world in terms of mammal species (Fonseca et al. 1996). Among the Brazilian biomes, the Cerrado (Brazilian savannah) is considered a global hotspot for the conservation of biodiversity (Myers et al. 2000) and has the third highest mammal species richness of Brazil with 251 species. Among these species, 12.75% ( $n = 32$ ) are

endemic to the Cerrado biome (Paglia et al. 2012), and 35 medium- and large-sized species are on the Brazilian list of endangered species (MMA 2014).

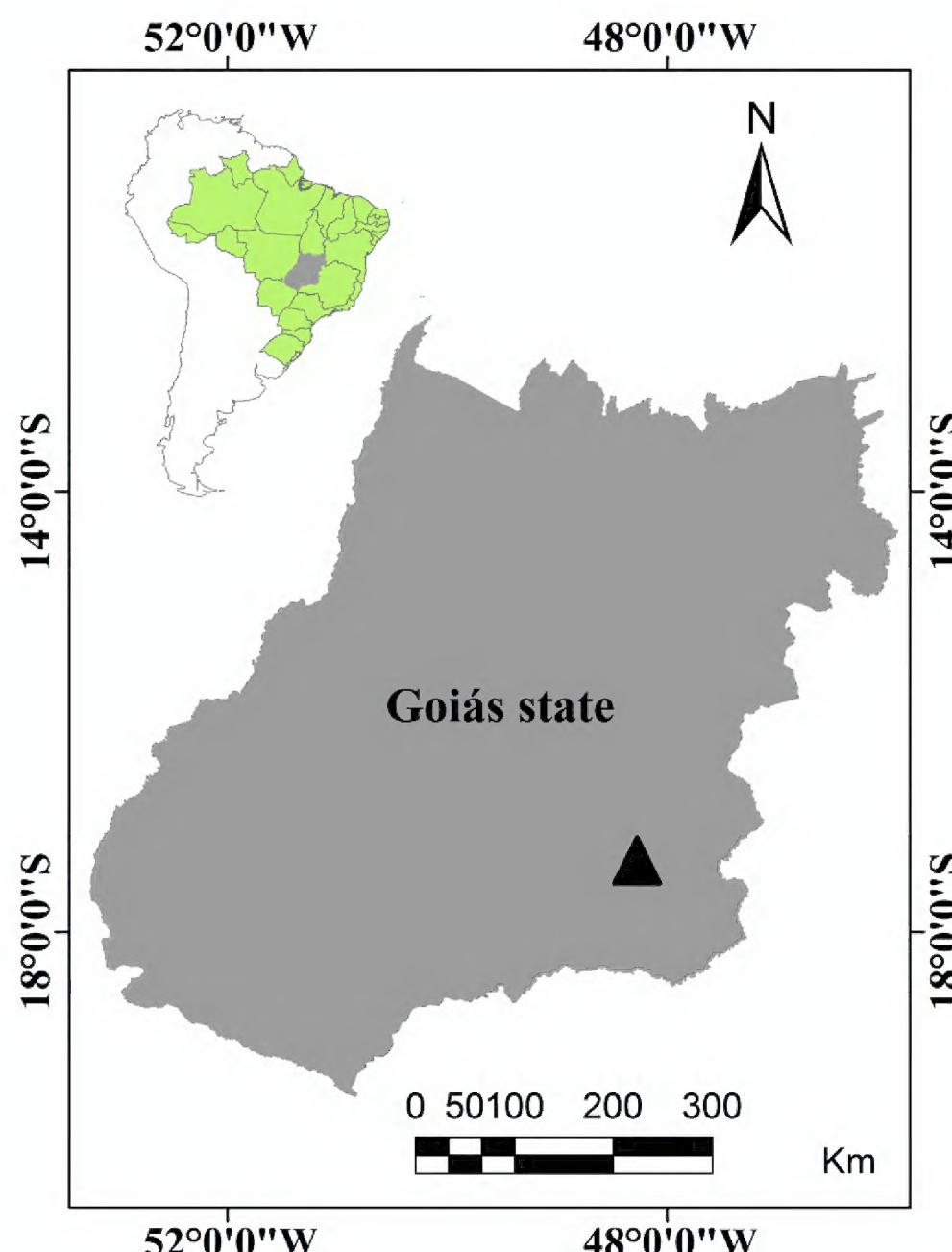
The high richness of the Cerrado mammal community can be explained by the influence of other biomes, such as the Amazonia and the Atlantic Forest (Costa 2003; Johnson et al. 1999). However, the Cerrado suffers from intense anthropogenic effects, including accelerated habitat degradation and subsequent fragmentation (Grecchi et al. 2014). Currently, only 47% of the original coverage remains, and it is distributed very unevenly (Beuchle et al. 2015).

The habitat fragmentation can cause important changes in the mammal community, specially the medium and large-sized ones, by reducing their structural complexity and the species richness (Chiarello 1999). The populations of large carnivores can be even more sensitive to anthropic changes, undergoing the direct impacts of hunting and being exposed to higher extinction risks as the density of humans in the areas occupied by these animals increases (Woodroffe 2000). The conflict between humans and wild animals has been reported by several authors (Graham et al. 2004; Mendonça et al. 2011; Ciuti et al. 2012; Alves et al. 2012; Margalida et al. 2014), who suggest that such conflict is one of the main threats to the preservation of the animal populations. Besides, some medium- and large-sized mammals are hunted as a form of population control, either because these animals are considered dangerous to humans or because they cause damage to plantations and attack domestic animals (Alves et al. 2012).

In relation to the Cerrado fragmentation, the less conserved areas are found in the states of Goiás, Minas Gerais, São Paulo and Mato Grosso do Sul. There is a

clear gap regarding the knowledge of mammals in the state of Goiás and there is no list of endangered animals for the state (Chiarello et al. 2008), which reinforces the need to develop studies that aim to understand and evaluate the status of the regional mammal fauna.

In face of the anthropic impacts to medium- and large-sized mammal species (Chiarello 1999; Woodroffe 2000) and the gaps in sampling areas where these animals occur (Costa et al. 2005), the objective of the present study was to provide an inventory and assessment of the diversity of medium- and large-sized mammal species in the fragmented Cerrado region in the municipality of Urutáí, southeastern state of Goiás.



**Figure 1.** Map of Goiás state (gray), in Brazil; triangle represents the study area, in Goiano Federal Institute.

## MATERIALS AND METHODS

### Study site

The study was conducted in an area of fragmented and anthropically modified Cerrado biome, belonging to the Goiano Federal Institute – Urutáí Campus [Instituto Federal Goiano – Campus Urutáí (IF Goiano – Campus Urutáí)], which is located in the Urutáí municipality, state of Goiás, Brazil (Figure 1). The municipality is located in southeastern Goiás ( $17^{\circ}27'52.73''S$ ,  $048^{\circ}12'6.78''W$ ), a region denominated the Goiás Massif, which predominantly consists of plateaus with altitudes between 685 and 988 m (Silva 2003).

According to the Köppen-Geiger classification, the region has a humid tropical climate (Aw) with a dry season and an average annual temperature of  $23.4^{\circ}C$ . There are two distinct seasons: a rainy season from October to March and a dry season, from April to September. The average annual rainfall is 1,402 mm, and there is a dense drainage network (Melo 1995).

The study area totaled 512 ha and is characterized by a mosaic formed by fragments of native Cerrado vegetation with different vegetation physiognomies (Riparian Forest, Gallery Forest and Semideciduous Forest in various successional stages) and areas used for grazing, agriculture and civil construction.

### Data collection

We used Wilson and Reeder's (2005) taxonomic classification system. All mammal species recorded during surveys were annotated except bats, small rodents, and marsupials ( $<1$  kg of body weight).

The sampling was conducted between the months of June 2013 and June 2014. We used direct observation methods and indirect observation methods (traces of animal presence, such as scratches, footprints, feces and dens) to sample the transects. We also employed a Trophy Cam (119456 Bushnell®) camera trap in stations outside the transects.

The sampling period in the transects totaled 28 sampling units, divided in morning, afternoon and night shifts, in 10 transects, with a minimum of two repetitions per transect and an average duration of 5 h in each unit. In the daily observations the transects were covered on foot; during the night, a car was used, keeping an average speed of 20 km/h. The camera trap was positioned an average of 30 cm from the ground and remained at each sampling station for 15 days, totaling 347 days. Bait, consisting of sardines and bananas, was placed close to the camera traps to increase the success of the survey. We used the works of Mamede and Alho (2008) and Azevedo and Lemos (2012) as references for species identification.

### Data analysis

Species richness was estimated by producing species accumulation curves and increasing sampling effort between sample units in transects and camera trapping in an independent way, in order to assess sampling efficiency by the effort made (Colwell and Coddington 1994). The mean accumulation curves were obtained for one nonparametric estimator – Jackknife 1, which considers as rare a species that appears in only one sample (Heltshe and Forrester 1983). The Jackknife 1 estimator yielded the smallest standard error values and confidence interval. It also reflects the curve stabilization (Santos 2003) as shown in Bocchiglieri et al. (2010). The curves were drawn by means of the EstimateSWin 8.2 program (Colwell 2013). The confidence interval of the

estimated species richness (95 %) was calculated using Statistica software (version 7.0).

## RESULTS

We recorded, in the study area, 25 mammal species belonging to eight orders (Table 1). Twenty-two were

recorded along the transects, 15 by camera trapping, and one by direct observation outside the sampling period. Of these, *Didelphis albiventris* Lund, 1840 and *Sylvilagus brasiliensis* Linnaeus, 1758 are considered to be small-sized mammals (< 1 kg of body weight) and were included in the present inventory and in the

**Table 1.** Species sampled in the study area and the type of record and conservation status based on the international list of threatened species (IUCN) and *Lista Nacional Oficial de Espécies da Fauna Ameaçadas de Extinção* – National Official List of Endangered Fauna Species (MMA 2014). Fo – footprints, Vi – visualization, Fe – feces, Sc – scratches, CT – camera trap, La – lair. Conservation status: LC – least concern, NT – near threatened, VU – vulnerable, DD – data deficient, NI – not included.

Taxon	Common name	Record	Status			
			IUCN	Brazil		
<b>ORDER ARTIODACTYLA</b>						
<b>Family Cervidae</b>						
<i>Mazama gouazoubira</i> (G. Fischer, 1814)	Brown Brocket	Fo, Fe, CT	LC	NI		
<b>Family Tayassuidae</b>						
<i>Pecari tajacu</i> (Linnaeus, 1758)	Collared Peccary	Fo, Vi, Fe, CT	LC	NI		
<b>ORDER CARNIVORA</b>						
<b>Family Canidae</b>						
<i>Cerdocyon thous</i> (Linnaeus, 1766)	Crab-eating Fox	Fo, Fe, CT	LC	NI		
<i>Chrysocyon brachyurus</i> (Illiger, 1815)	Maned Wolf	Fo, Fe	NT	VU		
<i>Lycalopex vetulus</i> (Lund, 1842)	Hoary Fox	Fo, Vi, Fe	LC	VU		
<b>Family Felidae</b>						
<i>Leopardus pardalis</i> (Linnaeus, 1758)	Ocelot	Sc, CT	LC	NI		
<i>Puma concolor</i> (Linnaeus, 1771)	Puma	Sc	LC	VU		
<b>Family Mephitidae</b>						
<i>Conepatus semistriatus</i> (Boddaert, 1785)	Striped Hog-nosed Skunk	Fo, Vi	LC	NI		
<b>Family Procyonidae</b>						
<i>Procyon cancrivorus</i> (G. Cuvier, 1798)	Crab-eating Raccoon	Fo	LC	NI		
<i>Nasua nasua</i> (Linnaeus, 1766)	South American Coati	Fo, Sc, CT	LC	NI		
<b>Family Mustelidae</b>						
<i>Eira barbara</i> (Linnaeus, 1758)	Tayra	Fo, CT	LC	NI		
<i>Lontra longicaudis</i> (Olfers, 1818)	Neotropical Otter	Vi	DD	NI		
<b>ORDER CINGULATA</b>						
<b>Family Dasypodidae</b>						
<i>Cabassous unicinctus</i> (Linnaeus, 1758)	Southern Naked-tailed Armadillo	Vi, La	LC	NI		
<i>Dasypus novemcinctus</i> Linnaeus, 1758	Nine-banded Armadillo	Fo, CT, La	LC	NI		
<i>Euphractus sexcinctus</i> (Linnaeus, 1758)	Yellow Armadillo	Fo, CT, La	LC	NI		
<i>Priodontes maximus</i> (Kerr, 1792)	Giant Armadillo	CT, La	VU	VU		
<b>ORDER DIDELPHIMORPHIA</b>						
<b>Family Didelphidae</b>						
<i>Didelphis albiventris</i> Lund, 1840	White-eared Opossum	CT	LC	NI		
<b>ORDER LAGOMORPHA</b>						
<b>Family Leporidae</b>						
<i>Sylvilagus brasiliensis</i> (Linnaeus, 1758)	Tapeti	Vi, CT	LC	NI		
<b>ORDER PILOSA</b>						
<b>Family Myrmecophagidae</b>						
<i>Myrmecophaga tridactyla</i> Linnaeus, 1758	Giant Anteater	Fo, Vi, Fe, CT	VU	VU		
<i>Tamandua tetradactyla</i> (Linnaeus, 1758)	Southern Tamandua	Vi, CT	LC	NI		
<b>ORDER PRIMATES</b>						
<b>Family Cebidae</b>						
<i>Sapajus libidinosus</i> (Spix, 1823)	Bearded Capuchin	Vi	LC	NI		
<b>ORDER RODENTIA</b>						
<b>Family Erethizontidae</b>						
<i>Coendou prehensilis</i> (Linnaeus, 1758)	Brazilian Porcupine	CT	LC	NI		
<b>Family Caviidae</b>						
<i>Hydrochoerus hydrochaeris</i> (Linnaeus, 1766)	Capybara	Fo, Fe	LC	NI		
<b>Family Dasyprotidae</b>						
<i>Dasyprocta azarae</i> Lichtenstein, 1823	Azara's Agouti	Fo	DD	NI		
<b>Family Cuniculidae</b>						
<i>Cuniculus paca</i> (Linnaeus, 1766)	Spotted Paca	Fo, CT	LC	NI		

species richness estimation because of their reliable identification, similar to the studies by Chiarello (2000) and Prado et al. (2008). After the sampling period, *Lontra longicaudis* (Olfers, 1818) was recorded and included in the species list, but was excluded from the species richness estimation.

The species richness estimated by the Jackknife 1 method totaled 24.89 ( $\pm 1.61$ ) species in transects and 16.88 ( $\pm 1.29$ ) by camera trapping in the study area (Figure 2) based on the presence/absence of 22 mammal species in transects and 15 by camera trapping.

The order Carnivora exhibited the highest species richness, accounting for 40 % ( $n = 10$ ) of the recorded species, followed by Cingulata and Rodentia, each with 16% ( $n = 4$ ).

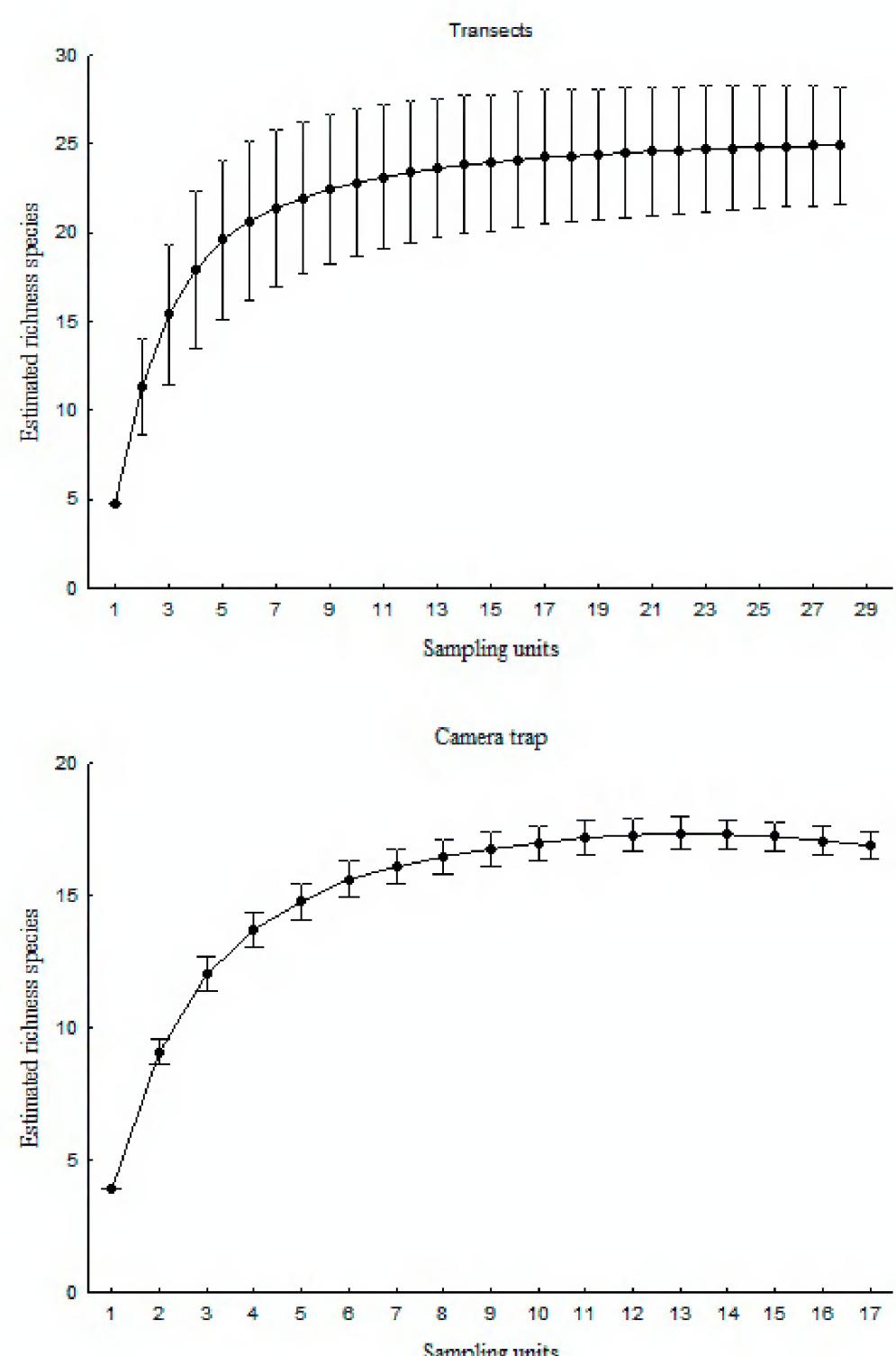
Among the identification methods used, the camera trap and footprints had higher numbers of species recorded, each with a total of 60% ( $n = 15$ ) of the species. In addition, 32% ( $n = 8$ ) of the species were recorded by only one sampling method.

Among the native mammals recorded (Table 1), five are included on the Brazilian List of Endangered Species (MMA 2014): *Chrysocyon brachyurus* (Illiger, 1815), *Lycalopex vetulus* (Lund, 1842), *Puma concolor* (Linnaeus, 1771), *Myrmecophaga tridactyla* Linnaeus, 1758 and *Priodontes maximus* (Kerr, 1792). Among these, three were also included in the international list of threatened species (IUCN 2014.2): *C. brachyurus* as “near threatened” and *M. tridactyla* and *P. maximus* as “vulnerable”.

In addition to the 25 native species, three exotic species were recorded in the study area: the domestic dog (*Canis lupus familiaris* Linnaeus, 1758), cattle (*Bos taurus* Linnaeus, 1758) and the domestic cat (*Felis catus* Linnaeus, 1758). The exotic species occurred predominantly in anthropically modified areas, being sporadically recorded in less disturbed areas.

## DISCUSSION

This study showed high species richness compared to other inventories in the state of Goiás and the presence of endangered species is also noteworthy. Silva (2012) inventoried 20 medium- and large-sized mammal species in a municipality neighboring Urutai through direct and indirect methods. In Goiás, other studies had previously recorded 23 species from the Silvânia National Forest (Campos and Lage 2010) and 28 species in Emas National Park (Silveira et al. 2003), both in conservation units. Outside of conservation units, 16 species were recorded in a study by Ribeiro and Melo (2013), 13 species were recorded by Bernardo and Melo (2013), and 19 species were recorded by Araújo et al. (2015). Thus, the area inventoried exhibited the highest species richness of medium- and large-sized mammals outside conservation units in the state of Goiás. It is possible that the mosaic nature of the study area contributed to



**Figure 2.** Species accumulation curve of medium and large-sized mammals recorded in transects and camera traps in the Cerrado area of Urutai, Goiás, Brazil. The data were expressed in species richness estimates calculated using the Jackknife 1 method and 95% confidence intervals.

the high mammal richness found in the present study, since the large-sized mammal species need larger areas for foraging and diversified environments to explore a large resource variety (Lyra-Jorge et al. 2008; Brady et al. 2011).

The sampling methods used were effective for recording the species and showed evidence of a high species richness. Footprints and camera trapping were demonstrated to be the most effective methods to detect mammals. Likewise, these methods were effective in Ribeiro and Melo (2013), Prado et al. (2008) and Silva (2012). According to Silveira et al. (2003), camera trapping is the most appropriate method for mammal inventory in all environmental conditions. However, the high percentage of species recorded by only one sampling method reinforces the importance of combining different methods to increase the capture success.

The estimated species richness had calculated 1.88 species by camera trapping and 2.89 species in the

transects beyond the observed species richness (Figure 2), and together with the stabilization of the species accumulation curves, this indicates that the sampling effort was sufficient for obtaining a robust inventory of the local mammal species, as highlighted by Heltshe and Forrester (1983).

In addition to the native species, also recorded were domestic ones which are recognized as disease vectors and as predators of wild animals. Dogs (*Canis lupus familiaris*) and cats (*Felis catus*) are the domestic animals considered to be the most common and widespread invasive exotic species worldwide, living in intense association with humans (Butler et al. 2004; Ferreira et al. 2011). A hunting blind located in a tree, most likely used by hunters in the region, was also found. The mentioned threats, along with habitat fragmentation and loss, indicate strong pressures on this rich mammalian fauna in the area studied.

Such threats require special attention, particularly for the 5 species regarded as endangered by the Brazilian list (MMA 2014). This significant number is higher than that in other studies in the state, such as Campos and Lage (2010) with three endangered species and Bernardo and Melo (2013) with one endangered species; these results are similar to other studies such as Ribeiro and Melo (2013) and Silva (2012), both with five endangered species. However, this number may be underestimated, as discussed by Chiarello et al. (2008), because of the lack of a state list of endangered species.

Until the publication of the work by Chiarello et al. (2008), lists of endangered species were available for six Brazilian states (Rio Grande do Sul, Paraná, São Paulo, Rio de Janeiro, Minas Gerais and Espírito Santo), with 53 endangered species present in one or more states that were not on the national list. Some of these species were included in the lists of the six states, such as the South American Tapir (*Tapirus terrestris*), the White-lipped Peccary (*Tayassu pecari*) and the Collared Peccary (*Pecari tajacu*).

The study area has high mammal diversity, including the presence of endangered species, and is not within any conservation unit. Thus, it is prone to various risks. This study contributes to the knowledge of Cerrado mammal species and indicates the need to adopt conservation measures for the regional conservation of the mammalian fauna.

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